The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Truck/Pavement/Economic Modeling and In-Situ Field Test Data Analysis Applications Volume 1: Influence of Drainage on Selection of Base

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Problem

Base materials should be properly selected for specific types of pavements to improve their overall performance. This implies that design procedures should not only consider material strength, but also the interaction between material layers. Base types considered in this study included granular (GB), lean concrete (LCB), asphalt treated (ATB), cement treated (CTB), and permeable asphalt treated (PATB) bases.

Objectives

This study used data obtained from test roads in Ohio and North Carolina to compare the performance of different base types under asphalt concrete (AC) and Portland cement concrete (PCC) pavements. Data on subsurface moisture, nondestructive tests, and visual distress surveys were reviewed to determine the best type of base for both AC and PCC pavements.

The ultimate objectives of the project were to provide design guidelines for reducing moisture in pavement structures and to identify the need for under drain systems.

Description

The long Term Pavement Performance (LTPP) Seasonal Monitoring Program (SMP) sites investigated in this report included four SMP sections in the North Carolina SPS-2 experiment on US52 and thirteen SMP sections in the SPS-1 and SPS-2 experiments on the Ohio SHRP Test Road on US23. These sites contained 10 GB, 4 LCB, 1 ATB, and 2 PATB sections. The NC sections are located in a wet-no-freeze zone and the OH sections are located in a wet-freeze zone. The presence of different bases under different sections of the same test road at the same location allowed for comparison of results under the same environmental conditions.

Time domain reflectometry (TDR) probes were used to record subsurface moisture content.

Falling weight deflectometer (FWD) tests were conducted during the construction of the Ohio Test Road. Similar tests were also conducted on the completed North Carolina test road at different times of day and at different locations on the slab to measure the effects of PCC slab curling.

Surface distress surveys were conducted periodically to monitor pavement deterioration.

Conclusions

Because of differences in the stiffness of asphalt concrete and Portland cement concrete, rigid pavement performance is less sensitive to subgrade stiffness than flexible pavement performance. LTPP data support the hypothesis that the relative stiffness between the pavement and the underlying layers affects fatigue life. Therefore, it is important to consider slab-base interactions when selecting an appropriate base for rigid pavement.

ATB provides the most uniform PCC slab support because of its ability to adapt to slab deformations.

Because of the rigidity of LCB, the level of support it provides is highly dependent upon PCC slab curling and warping. Although the k-value of LCB is very high, the loss of support caused by slab curling and warping results in poor performance.

PCC pavement sections with GB, which is the least expensive base material considered in this study, performed fairly well. However, GB is an erodable base. Pumping can be minimized by joint seals, load transfer devices, and proper maintenance.

LTPP DataPave data indicated that PCC pavement sections with PATB performed better than those with GB and LCB. PATB bases provided more uniform support for deformed slabs and faster drainage capability.

While ATB was not a part of the SPS-2 experiment, one ATB section was added as a supplemental section in NC. Performance data indicated that PCC on ATB performed better than on PATB. ATB was stiffer, less permeable, and more stable than PATB.

The selection of base material for flexible pavements is dependent upon subgrade stiffness and uniformity. The current density-based acceptance specification can not support this requirement.

Of the four types of base studied, LCB (CTB) is the stiffest base and PATB is the softest.

FWD test results suggest that to effectively improve support of the surface course, there may be a minimum thickness for different types of base.

Moisture data and field observations suggested that contraction cracks in LCB or CTB can be a direct channel for water intrusion that weakens the pavement structure.

Recommendations

Based on these results, it is hypothesized that there is a minimum thickness requirement for different types of bases to function and effectively improve subgrade support. Further research is needed to identify what these minimum thicknesses are.

LTPP data indicated that PCC on LCB performed poorly. This stiff base shall be avoided by all means.

ATB is by far the best base material for PCC pavements. An optimal choice for rigid pavement base may be an ATB with some drainage capability. Further study is needed to confirm this finding.

GB is a low cost base material. It performed well and can be a viable base for lower traffic PCC pavement facilities.

The selection of an appropriate base material for flexible pavements depends upon subgrade strength, thus requiring good subgrade stiffness data.

The following guidelines for base selection under flexible pavements are recommended:

1. For weak or highly variable subgrades, use bases with high stiffness, such as CTB, ATB, or very thick (> 300 mm (12 in)) GB. Cement/Lime stabilization may be used to improve subgrade stiffness and uniformity. CTB must be covered with thicker AC layers (>150 mm (6 in)) to minimize reflection cracking.
2. For strong, uniform subgrades, GB and ATB are suitable choices.
3. CTB must be at least 150 mm (6 in) to prevent damage by occasional heavy loads. An in-depth analysis needs to be performed to verify this minimum thickness requirement.
4. A 200 mm (8 in) or thicker GB increases both stiffness and uniformity of the finished surface. The use of GB less than 200 mm (8 in) in thickness should be limited to low volume roads.
5. The 200 mm (8 in) ATB provides more uniformiformity throughout the pavement section than the 100 mm (4 in) thick ATB. For high traffic conditions, consider 200 mm (8 in) thick ATB as a minimum.

Although most of these recommendations may not significantly impact construction costs, further research is needed to evaluate their cost-effectiveness.

Implementation Potential

These recommendations may be implemented initially by distribution of a memorandum to design engineers throughout all ODOT districts.

Subsequent implementation would include revision of specifications and other standard guidelines.